# SECTION 15050

# BASIC MATERIALS AND METHODS FOR MECHANICAL WORK

## PART 1 – GENERAL

### 1.1 DESCRIPTION OF WORK

**A.** Work Included: This Section specifies general requirements and basic materials and methods for mechanical work as necessary to support the sections in Division 15 which specify particular categories of mechanical work.

### 1.2 SUBMITTALS

**A.** List of Materials. Within 35 days after receipt of Notice to Proceed, submit to the Engineer a list of materials and equipment proposed for use together with applicable standards compliance. Give name of manufacturer, brand name, and catalog number of each item. Submit the list complete at one time, with items arranged and identified in numerical sequence by Specification Section and Article number.

**B.** Standards Compliance

1. Where equipment or materials are specified to conform to requirements of the standards of organizations such as ASTM, ANSI, ASME, UL, ARI and ASHRAE, submit evidence of such conformance to the Engineer for record purpose.

2. The label or listing of the specified agency will be acceptable evidence.

3. In lieu of the label or listing, the Contractor may submit a written certificate from an approved, nationally recognized testing organization, adequately equipped and competent to perform such services, stating that the items have been tested and that the units conform to the specified standard.

4. Where equipment is specified to conform to requirements of the ASME boiler and Pressure Vessel Code, Section VIII, the design, fabrication, and installation shall conform to the code in every respect.

**C.** Factory Test and Inspection Certification

1. Except as otherwise specified herein, factory tests and inspections for materials and equipment for which tests and inspections are specified in referenced documents, are waived, provided certified copies of test reports performed on previously manufactured identical materials or equipment are submitted to the Engineer.

2. Test reports shall be accompanied by signed statements from the manufacturer certifying that the previously tested material or equipment is physically, mechanically, and electrically identical to that proposed for the project. Wiring and control drawings shall be included.

**D.** Shop and Working Drawings. Show complete details of the following for installation of equipment including equipment furnished by others:

1. Foundations for equipment mounting.

2. Information for setting bolts in foundations.

3. Mounting methods, including isolation pads, showing adjustment and alignment.

4. Pipe anchors, supports and guides.

5. Details of installation of temporary materials and equipment to be used for the work.

6. Layout and complete details for piping and ductwork.

7. Plan for performing the work including the sequence of operations. Verify by field measurements and show on Working Drawings the exact location of existing utilities.

**E.** Installers' Qualifications. Submit certification of qualification of workers installing mechanical equipment, as required by Article 1.02 herein.

## 1.3 QUALITY ASSURANCE

**A.** Installation and testing of mechanical work shall be in accordance with this Specification and the instructions provided by equipment suppliers. Installers shall be qualified in accordance with the following requirements:

**B.** Welders: ANSI B31.1, Power Piping.

**C.** Ductworkers: Standard procedures, SMACNA Manuals. Furnish certification of qualifications by previous training and experience.

**D.** Plumbers and Pipe Fitters: Licensed by the Commonwealth of Massachusetts.

## 1.4 CONTRACT DRAWINGS

**A.** The Contract Drawings do not show all offsets, fittings and accessories that may be required. Investigate carefully the structural and finish conditions

affecting the work and furnish all such fittings and accessories as may be required at no additional cost to the Authority.

## 1.5 ELECTRICAL REQUIREMENTS

**A.** Provide electrical components of mechanical equipment and systems such as motors, motor starters and controls as specified hereinafter and as necessary for complete and operable systems.

**B.** Provide motors 1 HP and larger having a high apparent efficiency for energy conservation in their normal mode of operation. Select motors for the voltage specified; extended voltage range motors will not be permitted.

**C.** Provide interconnecting wiring for components of packaged equipment as an integral part of the equipment.

**D.** Interconnecting power wiring and conduit for field erected equipment, and control wiring, rated over 100 volts, and all conduit, shall conform to the applicable requirements of Division 16 of these Specifications.

## 1.6 PRODUCT DELIVERY, HANDLING AND STORAGE

**A.** Protecting Machined Surfaces. Apply a rust preventive on machined surfaces such as flanges and shafts. Use material of a type which is easily removable with solvent during equipment installation.

**B.** Covering Openings. Close pipe connections and other openings with easily removable plugs, stoppers or flange covers.

## 1.7 VERIFICATION OF DIMENSIONS

**A.** Visit the premises and thoroughly check details of work and working conditions, verify all dimensions in the field, and advise the Engineer of any discrepancy before ordering material and equipment or performing work. The Contractor shall be responsible for the coordination and proper relation of his work to the structure and to the work of all trades.

# PART 2 – PRODUCTS

## 2.1 STANDARD PIPE AND FITTING CLASSES

**A.** General: Service applications for following classes of pipe and fittings are specified in other sections of these Specifications, and may be indicated on the Contract Drawings. Where more than one class is indicated, either class may be used, but the classes shall not be intermingled.

**B.** Class A

1. Pipe and Fittings: ANSI/ASTM A 74, service weight, cast iron soil pipe and fittings.

2. Joints: packed oakum and molten lead; CISPI installation standards for caulked service weight soil pipe joints.

**C.** Class B

1. Pipe and Fittings: ANSI/ASTM A74, service weight, hub and plain end cast iron soil pipe and fittings.

2. Joints: Neoprene gasketed compression type; CISPI HSN.

**D.** Class C

1. Pipe and Fittings: ANSI/ASTM A74, extra heavy weight, bell and spigot cast iron soil pipe and fittings.

2. Joints: Lead and oakum; CISPI installation standards for caulked extra heavy weight soil pipe joints.

**E.** Class D

1. Pipe and Fittings: ANSI/ASTM A74, extra heavy weight hub and plain end cast iron soil pipe and fittings.

2. Joints: Neoprene gasketed compression type; CISPI HSN.

**F.** Class E

1. Pipe and Fittings: Service weight plain end cast iron soil pipe and fittings; CISPI 301.

2. Joints: Neoprene gaskets with corrosion-resistant clamps and bolts; CISPI 301.

**G.** Class F

1. Pipe: ANSI A40.5, cast iron threaded pipe.

2. Fittings: ANSI B16.12, cast iron recessed drainage type threaded fittings.

3. Joints: Threaded and coupled joints, ANSI B2.1.

**H.** Class G

1. Pipe: ANSI 21.51/AWWA C151, ductile iron pipe, thickness class as indicated, coated outside with bituminous coating and lined with cement mortar, thickness set by Table 51.2 of AWWA C151.

2. Fittings: ANSI A21.10.

3. Joints: Mechanical flanged joints with neoprene gaskets. Flanges to ANSI A21.11/AWWA C111, cast iron, flat face.

**I.** Class H

1. Pipe: Polyvinyl Chloride (PVC) ASTM D2665, Schedule 80, Type I, Grade 1.

2. Fittings: Socket weld, same material and schedule as pipe.

3. Joints: Socket welded with PVC solvent cement, ASTM D2564.

**J.** Class I: (Not used)

**K.** Class J

1. Pipe: ASTM B306, Type DWV. hard copper drainage tube.

2. Fittings: ANSI B16.23, wrought copper or bronze solder-joint drainage fittings.

3. Joints: Soldered.

**L.** Class K

1. Pipe: ASTM B88, Type L, hard copper tubing.

2. Fittings: ANSI B16.18 cast bronze solder fittings, or ANSI B16.22 wrought copper solder fittings and couplings.

3. Joints: Silver-brazed.

**M.** Class L

1. Pipe: ASTM B88, Type L, hard copper tubing.

2. Fittings: ANSI B16.18 cast bronze solder fittings, or ANSI B16.22 wrought copper solder fitting and couplings.

3. Joints: Silver brazed.

**N.** Class M

1. Pipe: ASTM B280, seamless copper tube, hard drawn.

2. Fittings: ANSI B16.18 cast bronze solder fittings, or ANSI B16.22 wrought copper solder fittings and couplings.

3. Joints: Silver brazed.

**O.** Class N: (Not used)

**P.** Class O: (Not used)

**Q.** Class P

1. Pipe 2 Inches and Smaller: ASTM A120, Schedule 40, black steel, beveled ends for welding.

2. Pipe 2-1/2 Inches and Larger: ASTM A135, Grade A or A139, Grade B, as indicated, Schedule 40, black steel, beveled ends for welding.

3. Fittings 2 Inches and Smaller: ASTM A105, Grade II, and ANSI B16.11, 2000 pound forged steel socket weld fittings.

4. Fittings 2-1/2 Inches and Larger: ASTM A234, and ANSI B16.9 standard weight butt welding fittings.

5. Joints 2 Inches and Smaller: Socket weld.

6. Joints 2-1/2 Inches and Larger: But weld.

7. Unions 2 Inches and Smaller: ANSI B16.3, malleable iron threaded.

8. Unions 2-1/2 inches and Larger: Flanged.

9. Flanges: ANSI B16.5 and ASTM A181, Grade I, forged steel, raised or insert face, 150-pound class, slip-on or welding neck to suit field conditions.

**R.** Class R

1. Pipe 2 Inches and smaller: ASTM A120 seamless, schedule 80, galvanized, threaded.

2. Pipe 2-1/2 Inches and Larger: ASTM A135 or A139, Grade A or B, black steel, beveled ends for welding.

3. Fittings 2 Inches and Smaller: ANSI B16.3, galvanized, malleable iron, threaded.

4. Fittings 2-1/2 inches and Larger: ANSI B16.9 and ASTM A234, extra heavy butt welding fittings.

5. Joints 2 Inches and Smaller: Galvanized, threaded and coupled.

6. Joints 2-1/2 inches and Larger: But weld.

7. Unions 2 inches and smaller; ANSI B16.3, malleable iron, galvanized, threaded.

8. Unions 2-1/2 inches and larger: Flanged.

9. Flanges: ANSI B16.5 and ASTM A181, Grade I, forged steel, raised or insert face, 150-pound class, slip-on or welding neck to suit field conditions.

**S.** Class S

1. Pipe: ASTM A120, or ANSI B36.10, Schedule 80, black steel, screwed, flanged or welded ends.

2. Fittings
   a. FS WW-P-501, Type and Class of fittings to match adjacent piping.
   b. FW WW-P-521, to match adjacent piping, per NFPA standards.

3. Joints
   a. 4 inches and larger: Butt weld in tunnels and where indicated.
   b. Under 4 inches: Threaded type except butt flanged where indicated, as required by NFPA standards.

4. Unions
   a. 2 inches and smaller: ANSI B16.3, malleable iron, threaded.
   b. 2-1/2 inches and larger: Flanged.

5. Flanges: ANSI B16.5 and ASTM A181, Grade I, forged steel, raised or plain faced 300-pound class.

**T.** Class T

1. Pipe: A 120, Schedule 40, black.

2. Fittings: ANSI B16.3, 150 pound, black.

**U.** Class U: Same as Class T except galvanized.

## 2.2 BRANCH TEES

**A.** Refrigeration Piping: Wrought copper, Schedule 80, soldered.

**B.** Welded Pipe (all): Welding or brazing outlets with branch size at least 2 sizes smaller than the main.

**C.** Copper Tubing: Brazing outlets, with branch size at least 2 sizes smaller than the main.

**D.** Match Schedule 40 or with appropriate outlets as required to match piping.

**E.** Forged, as indicated.

## 2.3 PIPE JOINT MATERIAL

**A.** Silver Brazing Alloy: AWS requirements, Class BC UP-5 for 1100 to 1500 degrees F melting temperature.

**B.** Solder: ASTM B32, Grade 95 TA, up to 250 degrees F.

**C.** Arc-Welding Electrodes: ASTM A 233, or as indicated.

**D.** Welding-Rods for Oxyacetylene Welding; AWS A5.2, ASTM A 251.

## 2.4 PIPE HANGERS AND SUPPORTS

**A.** FS WW-H-171, standard commercial product with the type as required for each particular application.

**B.** Anchors: FS FF-S-325, fastened as indicated.

## 2.5 VALVES

**A.** Backwater Valves, Flap Type: Cast-iron, ASTM A74, individual assembly, hinged or pivoted, with bronze rotating disc and seat.

**B.** Backwater Valves, Combination Type: Cast-iron, ASTM A74, Combination floor drain with P-trap flap type assembly, hinged or pivoted, with rotating disc.

**C.** Gate Valves

1. 2 Inches and Smaller: 150 pound bronze, non-rising stem, wedge disc, threaded connection; FS WW-V-54, Type I, Class B.

2. 2-1/2 Inches and Larger: 125 pound, iron body, non-rising stem, wedge disc, flanged connection; FS WW-V-58, Type I, Class I.

**D.** Globe and Angle Valves

1.General: FS WW-V-51, Type I or II, Class A or B.

2.2 Inches and Smaller: 150 pound, bronze, replaceable seat and disc, threaded connection.

3.2-1/2 Inches and Larger: 125 pound, iron body, bronze trimmed, replaceable seat and disc, bolted yoke bonnet, two-piece packing gland, flanged connection.

**E.** Check Valves

1.General: FS WW-V-51, Type IV, Class A or B, or as indicted.

2.Swing Check, 2 Inches and Smaller: 150 pound, bronze threaded connection, with removable hinge pin and screwed cap, suitable for operation in either horizontal or vertical position.

3. Swing Check, 2-1/2 inches and larger: 125 pound, flanged connection, with removable hinge pin and bolted cap.

4. Silent Check: Globe type, 150 pound, iron body, with disc guided top and bottom, bronze trimmed seat and plug, stainless steel spring, flanged connection.

**F.** Butterfly Valves

1. General: FS WW-V-1967, Type A or B, as indicated. Butterfly valves shall consist essentially of a body, disc assembly, stem, stem packing, removable packing retainer, operating lever, and appropriate end connections.

2. Seats: Type A valves shall be suitable for Class 175 for water, oil or gas (WOG) at any temperature in the range minus 20˚F to 125˚F; Type B, for Class 175 and any temperature from minus 30 degrees F to 350 degrees F.

3. Discs: Stainless steel. Materials which are of dissimilar metal with respect to the galvanic scale shall be separated from the valve body by an insulating material which prevents electrolytic corrosion.

4. Shaft Stems: Stainless steel, ASTM A 582, Type 304 or 316.

5. Control Handles: Suitable for locking in any position, or with 10 degree or 15 degree notched throttling plates to hold valve in selected position.

6. Valves in insulated lines: Provide extended necks to compensate for insulation thickness and allow ample clearance for operating handle.

**G.** Ball Valves

1. Lever-operated, 175 pound, non-lubricated eccentric plug type, with nickel-iron body, suitable for service with water at 250 degrees F. Provide with full round port and balanced plug coated with appropriate material for low torque and bubble-tight shut-off. Provide with position indicator on cap or side of body.

**H.** Compression Stops

1. Exposed Water Supplies to Fixtures: Polished, chrome-plated, loose key brass stop.

2. Concealed Supplies to Fixtures: Long-neck, built-in, loose key, with flange, for required wall thickness with exposed parts chrome plated.

3. Exposed Supplies at Hose Faucets: 125 pound, brass or cast iron body, brass plug, square head cock.

**I.** Air Vent Valves, Automatic: Float-type, with ball check discharge port threaded for 1/8 inch IPS drain connection, copper, clad steel float with stainless steel float pin, threaded and gasketed removable float housing, and cast brass base threaded for 3/4 inch male IPS connection.

**J.** Pressure Reducing Valves: All bronze construction, spring loaded, single seated, suitable for tight shut-off under dead-end conditions. Provide with renewable composition seat discs, nylon inserted diaphragm, bolted spring changer, and threaded connection.

**K.** Relief Valves:

1. General: Pressure and temperature relief for hot water supply systems, MIL-V-13612.

2. ASME rated for intended service: Single-seated, bronze body and trim, guides, adjusting screw with cap and threaded connections.

3. Hydraulic valves.

4. As required for the system indicated.

**L.** Hose Faucets: Brass, 1/2 inch male, inlet threads, 3/4 inch, hose connection, hexagonal shoulder.

## 2.6 UNIONS

**A.** Black Steel Pipe, 2 Inches and Smaller: FS WW-U-531, uncoated malleable iron or steel with brass or bronze seats, 150 pound, threaded.

**B.** Galvanized Steel Pipe, 2 Inches and Smaller: Galvanized with brass or bronze seats, 150 pound, malleable iron, threaded.

**C.** Copper or Brass Pipe or Tubing, 3/8 Inch and Smaller: 150 pound, cast bronze or copper, ground joint, nonferrous seat, with solder ends. Compression fittings for air service.

**D.** Copper or Brass Pipe, 1/2 Inch to 2 Inches: Cast brass, 150 pound, ground joint, brass-to-brass seat, with threaded ends.

**E.** Black and Nickel-Copper Alloy Steel Pipe, 2-1/2 Inches and Larger: Forged steel, 150 pound, raised face, slip-on or welding neck to suit field fit up.

## 2.7 FLANGES

**A.** Ductile Iron Pipes: ANSI A21.11, 250 pound, flat face, cast iron flanges for mechanical joints. ASTM A 307, Grade B, bolts and nuts. Bolts: Regular square head unfinished. Nuts: Heavy semi-finished hexagon nuts conforming to ASTM A 194, Grade 2H.

**B.** Welded Steel Pipe: ASTM A181, Grade I, 150 pound black forged steel welding flange, with 1/16 inch raised face. Use flat face when connected to flat-faced companion flange; slip-on to suite field conditions.

**C.** Copper, Bronze, or Brass Pipe: ANSI B16.24, 150 pound, cast bronze, flat-faced with solder ends, 1/2 to 12 inches.

## 2.8 GASKETS

**A.** Cold Water Service: MIL-G-13210, rubber, 1/16 inch thick.

**B.** Hot Water Service: Compressed aramid, 1/16 inch thick.

**C.** Soil, Waste, Vent and Drain: Neoprene rubber as required for type of pipes used, ASTM C 508, cellular elastomeric preformed gasket, and sealing material, ASTM C 364.

## 2.9 INSULATING CONNECTIONS

**A.** Provide insulating flanges or unions suitable for 125 pound working pressure and for services as required, constructed so that connected pipes are completely insulating from each other without metal to metal contact. Provide with metal connections at ends, threaded or soldered to match adjacent piping.

**B.** Insulating couplings will not be acceptable.

## 2.10 EXPANSION JOINTS

**A.** Pressure Rating: One hundred fifty psi minimum at 250 degrees F.

**B.** Type: Flanged, stainless steel, consisting of a corrugated bellows, capable of absorbing pipe movement in an axial or lateral direction. Provide with support rods to keep flange faces parallel during installation.

**C.** Pipe-alignment Guides: As recommended by the joint manufacturer but in any case not more than five feet on each side of each expansion joint, except in lines four inches or smaller they may be not over two feet each side of the joint.

**D.** Traverse Capacity of Joint: Not less than indicated.

## 2.11 ESCUTCHEONS

**A.** Finished Areas: Chromium plated, pressed or stamped brass, one piece, or split pattern, held in place by internal-spring or set screw.

**B.** Unfinished Areas: Galvanized metal disc or plates.

## 2.12 PIPE SLEEVES

**A.** Pipe Sleeves Through Interior Walls and Floors:

1. Clay: ASTM C4, Class as indicated.

2. Concrete: ASTM C14, non-reinforced, type as indicated.

3. Steel: ASTM A120 (1/8 thru 16 inches), A 53 (18 through 24 inches), or ANSI B36.10.

**B.** Pipe Sleeves Through Exterior Walls With Waterproofing or Damp Proofing: Cast iron, ASTM A74, pressure sealing with membrane clamp; cast body with external fins, internal pressure rings and grommet, pressure clamp with stainless steel bolts; oversize steel sleeve with neoprene sealing rings.

## 2.13 STRAINERS

**A.** Strainers: MIL-S-16293, Class 125, Style Y, Type I or III.

## 2.14 PROTECTIVE COATING FOR PIPE

**A.** Tape: Polyvinyl chloride or polyethylene pressure sensitive tape, nominal 20 mils thick, conforming to the following requirements:

1. Maximum Moisture Transmission Rate; 1.8 grams/100 square inch/24 hours.

2. Maximum Moisture Absorption; 0.57 percent.

3. Maximum Continuous Service Temperature; 175 degrees F.

4. Minimum Dielectric Strength; 20,000 volts.

5. Minimum Insulation Resistance; 500,000 megohms.

**B.** Two separate layers of 10 mil tape may be used for piping, except do not use single tape with half lap. Use same tape in 10-mil thickness for field joints and fittings.

**C.** Mark pipe wrapping to indicate manufacturer, number, and thickness.

**D.** Primers: Type specifically compounded for tape being used.

## 2.15 GAGES

**A.** Gages: FS GG-G-76, sizes as indicated.

**B.** Calibration: Calibrated to two percent in middle 1/3 of dial range and equipped with means of front calibration.

**C.** Movements: Phosphor bronze bushed, rotary type.

**D.** Panel Mounted: Flush mounting type in cast iron or aluminum cases.

**E.** Stem or Pipe Mounted: Flangeless cases of drawn or stamped steel, phenolic or aluminum.

## 2.16 THERMOMETERS

**A.** General: Red reading mercury column type with wide angle of vision and high magnification of mercury column, or heavy, one-piece, extruded or cast brass or aluminum construction with glass front. Thermometer scales: maximum two degree between graduation and 20 degree between figures. Provided steel bulb chambers and brass separable sockets.

**B.** Scale Lengths: Seven inches minimum for tanks and similar equipment, and five inches minimum for piping.

**C.** Optional: Dial thermometer with five-inch dials and liquid-filled thermal systems.

## 2.17 ACCESS PANELS

**A.** General: This Article applies to prefabricated wall and ceiling panels for service access to equipment. For doors and access panels in sheet metal ductwork and plenums, see Section 15800 - AIR DISTRIBUTION.

**B.** Size: Large enough to permit removal of equipment and in no case less than 12 by 12 inches net opening. Where entrance of serviceman is required, provide minimum opening of 12 by 24 inches.

**C.** Construction:

1. In Ceilings:

    a. Fire Rated: UL listed for minimum one hour rating, with concealed hinge and screwdriver-operated cam latch. Construction at least equal to that listed in Subparagraph 1.b below.
    b. All Other: Doors, 16 USS gauge minimum; frames, 18 USS gauge minimum, with concealed hinge and screwdriver-operated cam latch.
    c. Finish: Factory prime coat.

2. In Toilet Rooms and Ceramic Tile Walls: Construction same as Subparagraph 1.b above, with polished stainless steel face.

## 2.18 ELECTRIC MOTORS

**A.** General: Provide motors so that load on driven equipment will not exceed motor rated capacity under most severe conditions to be encountered; single phase motors up to 1/2 HP, all others three phase.

**B.** Standards: Latest editions of applicable standards of NEMA, IEEE and ANSI.

**C.** Voltage: As indicated.

**D.** Enclosures:

1. Indoor Use: Drip-proof with drain plugs or other openings for condensate drainage.

2. Outdoor Use: Totally enclosed, non-ventilated, or fan-cooled type.

**E.** Motor Types:

1. Polyphase: NEMA Design B, squirrel cage, normal starting torque, low slip, with antifriction ball-bearings.

2. Single Phase: Capacitor-start, induction-run, with ball bearings or sleeve bearings.

**F.** Service Factor:

1. Drip-Proof Motors; 1.15.

2. Totally Enclosed; 1.0.

**G.** Insulation:

1. Class B, except as indicted.

2. Open Drip-Proof Motors: Insulation system completely sealed and coated with abrasion resistant material such as polyurethane. Provide corrosion treatment on rotors, stators, end shields and air deflectors.

## 2.19 VIBRATION ISOLATORS

**A.** General

1. Isolate mechanical equipment and associated piping and ducting as required to minimize transmission of vibration and structure-borne noise to structure or spaces.

2. Select and install isolation in accordance with the isolator manufacturer's instructions. Submit for review and approval before installation, isolator selection calculations and details.

3. Furnish services of a trained manufacturer's representative to inspect the completed installation.

**B.** Spring Isolators

1. Isolators: Freestanding, laterally stable and complete with neoprene pads as specified herein. Provide springs with coil outside diameter not less than 0.8 of the coil operating height. Springs shall have an additional travel to solid equal to 50 percent of design static deflection. Yield stress of spring material shall not be exceeded when the spring is fully compressed.

2. Top and Bottom Spring Support Plates: Welded to spring and dimensioned to prevent any visible defection when loaded. Size bottom plate for proper loading of neoprene pad and provide in square configuration.

3. Spring Isolator Assembly: Provide a minimum of three height adjustment bolts, a precompression bolt and vertical restraint bolts. Furnish spring isolators precompressed to facilitate installation. Vertical restraint and precompression bolts shall be out of contact with the isolator during normal operations.

4. Spring Isolator Coating: Galvanized or neoprene coated where installed exposed to weather.

5. Static Deflection: As indicated or as required in these Specifications.

**C.** Neoprene Isolating Pads: Neoprene, 40A durometer hardness, 1/2 inch thick, permanently bonded to the underside of the bottom spring isolator plates. Dimension for uniform loading not to exceed 50 psi.

## PART 3 – EXECUTION

### 3.1 GENERAL

**A.** Protection of the Work

1. Cover openings in ductwork, conduits and piping and temporarily seal to protect from contamination.

2. Protect materials and equipment from damage due to environmental conditions. Use protective cover, and protect from surface water by using raised platforms.

3. Protect unfinished work at the end of each day from damage, contamination, and moisture, by the use of plugs, caps, or covers.

4. Do not lay pipe on a foundation into which frost has penetrated, nor at any time when the Engineer determines there is danger of ice formation or frost penetration at the bottom of the excavation.

5. Protect piping and valves from damage pending performance of system tests.

6. Protect installed thermometers and gauges from accidental damage by construction activity.

7. Following installation, and prior to final embedment, use temporary protective covers and fixtures to prevent damage from all traffic and overburden loads which would damage or displace embedments.

8. Clean fixtures, piping, valves, finished brass, and equipment installed under this work. Drain and flush piping to remove grease and foreign matter. Flush air and gas piping with compressed dry nitrogen.

**B.** Location of Fixtures and Equipment

1. The mechanical sheets of the Contract Drawings are diagrammatical and not intended for use in determining the exact locations of the components of mechanical and electrical systems.

2. Refer to applicable sheets of the Contract Drawings to determine the exact location of fixtures and equipment to be installed under the Contract as well as the location of items indicated on the Contract Drawings to be installed by others.

## 3.2 INSTALLATION OF PIPING

**A.** General

1. Install piping parallel to walls where possible and desirable. Clear all obstructions, preserve headroom and keep openings and passageways clear.

2. Should structural difficulties or other work prevent running of pipes or setting of equipment at locations indicated, necessary minor deviations therefrom will be allowed, as approved by the Engineer.

3. Run piping in chases or recesses in walls where provided, through openings in floors, and in furred ceilings; otherwise, as exposed pipes. Do not embed piping in or below structure, except as indicated.

4. Expanding or swaging of tubing to fit IPS fitting sockets will not be permitted.

5. Use reducing fittings where change in pipe size occurs.

6. Use couplings only where required pipe runs between fittings are longer than standard length of pipe being used.

7. Make exposed polished or enameled connections to fixtures or equipment with special care to avoid damage to finished surfaces.

8. Make changes in direction only with fittings.

9. Provide expansion loops (bends) where indicated to allow for proper pipe expansion. Construct bends with long radius welding fittings unless otherwise indicated.

10. Use proper length bolts for each size flange on flanged connections. Bolts with excessive length of exposed threads will not be permitted. A minimum of three full threads is required to be exposed beyond the nut after tightening the assembly.

11. Prevent entry of foreign matter during handling, assembling and installation. Use compressed air, wire brush, solvent and other acceptable means to remove residual scale, dirt and other foreign matter from interior of piping before final connections are made. Protect open ends of pipe by capping, plugging or other acceptable means.

12. Anchor piping subject to expansion or contraction in a manner permitting strains to be evenly distributed and alleviated by swing joints or expansion loops.

13. Flush out and blow out piping systems as specified under "Protection, Care and Cleaning".

14. Ream pipe ends to remove burrs.

15. Install all piping with sufficient pitch to insure adequate drainage and venting.

16. Provide unions or flanges in piping connections to equipment.

17. Electrically isolate connections between ferrous piping and piping with dielectric couplings or fittings.

18. Install class of piping as indicated.

19. Do not run water piping over electric switchboards, transformers, or electric motor starters.

20. Protect against external corrosion pipes which pass through, under, or otherwise in contact with soil, cinders, concrete, or other corrosive material. Protect by protective wrappings, as specified, or by other means approved by the Engineer.

**B.** Hot Water Heating System Piping: Slope piping not less than 1/4 inch per foot, upwards, in the direction of flow.

**C.** Sewer, Waste and Storm Drain Piping

1. Run horizontal drainage piping as straight as practicable, and at a uniform pitch.

2. Install pipe 3 inches or less in diameter with a pitch of not less than 1/4 inch per foot.

3. Install pipe larger than 3-inch diameter with a pitch of not less than 1/8 inch per foot.

4. Install storm or sanitary sewers within or adjacent to any building or structure at a slope which will produce a computed velocity of not less than 2 feet per second.

**D.** Compressed Air Piping: Pitch piping away from receiver to a low point or to a dead end; provide drips and traps with valves shut-off at all points. Make branch connections at top of main.

**E.** Refrigeration Piping: Size piping for the particular refrigerant being used, in accordance with ASHRAE standards.

**F.** Steam and Condensate Return Piping: For low-pressure heating system (15 psig and below) size pipe in accordance with ASHRAE Guide and Data Book.

## 3.3 INSTALLATION OF PIPE JOINTS AND CONNECTIONS

**A.** General

1. Cut pipe with appropriate tool; debur. Make joints tight. Test and remake leaky joints with new materials. Do not use thread cement or caulking to remake joints. Do not use a sharp-toothed wrench in making up brass pipe, or chrome plated items.

2. Thread forms and length shall be in accordance with ANSI standards. Use a lubricant or sealant on male threads suitable for the proposed pipe service.

3. Clean joint before soldering, use an appropriate flux and alloy for operating temperature level as indicated.

4. Install solvent-cement joints for PVC pipe in accordance with manufacturer's recommendations.

5. Apply the standard rules for the welding of pipe joints as contained in the ANSI Standard Code for pressure piping: including welding procedures, qualification of welders, and testing. Follow applicable local safety codes.

6. Provide a gasket coated with the recommended lubricant between the contact faces of the flanges.

**B.** Cast Iron Soil Pipe

1. Bell and Spigot Pipe. Make joints with caulking lead and gasket of packed oakum or dry jute. Use joint runner so lead will finish flush with bell. Caulk the joints tight, leaving not less than one inch of lead in bells. Run every joint full at one pouring.

2. Neoprene Gasketed Plain Spigot End Pipe. Insert gaskets, lubricate inside of gaskets and outside of pipe, and join together with suitable tool, as recommended by manufacturer.

3. Hubless Pipe: Assemble in accordance with Massachusetts Plumbing Code.

**C.** Copper Tubing Systems

1. Use silver brazed joints for refrigerant piping. Flow nitrogen through tubing to prevent oxidation during brazing.

2. For all other service, make joints with 95-5 tin antimony or (up to 250 degrees F.) 50-50 tin-lead solder.

3. Clean outside of tube and inside of fitting at point of contact before joining. Take care to prevent overheating of tube and fitting before joining. Before silver brazing, disassemble solder type valves used in refrigerant piping, and keep valve bodies cool by use of damp cloths or other approved methods.

**D.** Ductile Iron Mechanical Joint Water Pipe: ANSI A21.11

1. Outside Coating: Bituminous coating approximately 1 mil thick, with finished coating continuous, smooth, neither brittle when cold nor sticky when exposed to the sun and strongly adherent to the pipe.

2. Cement-Mortar Linings: ANSI A21.4.

3. Inside Coating: Unless otherwise specified, provide inside coating for pipe that is not cement-lined of bituminous material, at least 1 mil thick, which conforms to appropriate requirements for seal coat.

**E.** Drain Connections

1. Make all threaded joints with graphite or inert filler and oil, or of approved graphite compound, or with polytetrafluorethylene tape applied to male threads only.

2. Caulked joint as for bell and spigot pipe.

**F.** Steel Pipe and Welding Fittings. Make joints in welded piping by oxyacetylene or electric arc process with welding continuous around pipe. Welders shall be qualified per ANSI B31.1.

**G.** Polyvinyl Chloride Pipe

1. Threaded Joints. Make joints with teflon pipe joint compound, or teflon tape of type recommended by pipe and fitting manufacturer, suitable for service in which it is to be used, conforming to ANSI B2.1.

2. Flanged Joints. When required, flanged joints may be used to connect to equipment or to other piping materials. Flanged, socket typed molded PVC heavy 150-pound pattern, drilled per ANSI 16.5.

3. Welded Joints. Use solvent cement of type recommended by fitting manufacturer, suitable for service in which it is to be used. Joints shall be made by workmen skilled in technique of welding PVC pipe.

## 3.4 INSTALLATION OF PIPE SLEEVES

**A.** General

1. Provide a pipe sleeve where each pipe passes through a wall or floor and at other locations indicated. Sleeves through floor should project 1/2 inch above the finished floor.

2. Provide minimum of 1/2 inch radial clearance beyond pipe and pipe plus insulation, where required. Extend sleeve the full thickness of wall or floor. For high temperature, follow clearance requirements of NFPA.

3. Secure sleeves to concrete forms to prevent displacement during placing of concrete.

4. Where pipes pass through fire-rated walls, or floors, place a fire seal of aramid rope or similar non-combustible material between pipe and pipe sleeve for the full length of the sleeve to maintain fire rating.

**B.** Location and Types

1. At interior walls and floors provide permanent sleeves of clay pipe, concrete pipe, or steel pipe. Where sleeves cannot be installed such as connections to floor drains, pipes shall not be in contact with reinforcing steel. Caulk space between pipes and pipe sleeves with oakum and mastic and made watertight.

2. At exterior walls with waterproofing or dampproofing as specified herein, provide permanent sleeves of cast iron.

3. Clamp membrane into place and caulk with oakum and mastic in the caulking recess. At walls more than 15 feet below grade, provide a compression seal as indicated.

## 3.5 INSTALLATION OF PIPE HANGERS AND SUPPORTS

**A.** General

1. Provide above ground piping systems inside and outside building with anchorages, sway braces, guides and supports as required by applicable portions of ANSI B31 except as otherwise indicated.

2. Provide pipe supports as indicated. The necessary hangers and supports, including beam and purlin clamps, rods, pipe rolls, angles, channels and plates, as well as any changes from indicated design, shall have the Engineer's prior approval.

3. Use of building structural steel for supporting hangers will be permitted only where indicated or approved by the Engineer. Do not weld transversely across the tension flange of any member under stress; use bracing, grits, and other secondary members for support; or burn or drill holes in building steel.

4. Support vertical piping with approved steel brackets to prevent swaying, sagging, vibration and resonance; however, allow for thermal expansion between supports or anchors. Do not use flat steel strap hangers.

5. Do not support piping by wire, rope, strap, chain, wood or similar devices.

6. Provide pipe hangers of same size, or nearest commercial size available, as pipe or tubing on which they are to be used. Allow for thickness of insulation in sizing hangers.

7. Mount hose faucets, compressed air outlets, and similar items with short cantilevers at ends of pipe branches.

8. Supporting structures, including supporting frames, anchors and guides common to mechanical work and electrical work may be used unless specifically otherwise indicated.

9. When piping to equipment mounted on vibration isolators provide spring cushion or other approved type isolation hanger on the pipe support nearest, and on each side of, the equipment.

10. Except as otherwise noted, use adjustable iron hangers for 1-1/4 inch and smaller pipe, and clevis type for 1-1/2 inch and larger pipe. Where copper tubing is directly supported, use copper plated hangers.

11. Anchors for pipe hangers and supports:
    a. Cast-in-place weld plates as indicated.
    b. Anchor bolts placed in drilled holes with high strength cement grout. Dimensions and material as indicated.
    c. Expansion bolts, FS FF-S-325, set in drilled holes. Follow manufacturer's instructions for insertion and bolt anchoring. Dimensions as indicated; however, bolt embedment at least four times bolt diameter.

**B.** Supports for Insulated Piping

1. For insulated hot and cold lines, unless otherwise indicated, use pipe saddles welded to pipe lines as required for supporting piping from exterior of insulation. At time of installation, fill with insulating cement.

2. In lieu of saddles, pipe two inches and smaller may be supported form insulation with galvanized steel half round protective shields.

3. For vertical piping four inches and larger, provide angle or plate type insulation supports welded to pipe at approximately 12-foot intervals. Fabricate these supports of same material as pipe to which they are attached, and of widths less than thickness of insulation covering.

4. Install hangers around outside of low temperature insulation. Insert section of nine inch long by 180 degree cellular glass, minimum eight pounds per cubit foot density, with vapor barrier jacket plus 18-gage by 10 inch by 180 degree galvanized steel shield. Special hangers equipped with equivalent insulating material and vapor barrier may be used.

## 3.6 VALVES AND VALVE BOXES

**A.** General. Provide valves at all points shown and specified, arranged to give complete and regulating control of piping systems. Provide valves full size of line in which installed, unless otherwise indicated. Install valves with neat appearance and grouping, so parts are easily accessible for operation and maintenance. These are used in low temperature service with copper pipe. Install throttling flow valves where indicated, and on each circulating return branch on domestic hot water systems on hot water heating systems and on a chilled water system.

**B.** Compression Stops. Install stop valve or compression stop on water supply lines to each plumbing fixture, including faucets and showers. Where required for accessibility, install them exposed adjacent to faucets. Where fixture trim is specified with integral built-in stops, individual supply stops will not be required. Unions are not required adjacent to compression stops.

**C.** Air Vent Valves

1. Manual Air Vent Assemblies. Provide in hot water heating and chilled water cooling systems where indicated and at high points and other points necessary to free piping system of air. Connect 1/4 inch copper tubing to top of high point, or other location, and extend down to easily accessible 1/4 inch globe valve, mounted, grouped and tagged approximately five feet above floor. Discharge through 1/4 inch copper tubing to nearest floor drain, or as approved by the Engineer.

2. Automatic Type Air Vent Valves. Provide where indicted, installed on short 3/8 inch minimum riser with glove valve in riser. Provide full size copper tubing drain line from automatic valve to nearest floor drain, or as approved by the Engineer.

**D.** Chain Operators. Provide for valves located in exposed overhead piping seven feet or more above floors in mechanical equipment rooms.

**E.** Pressure Reducing Valves. Install reducing stations along walls or other available spaces with arrangement to permit easy access for servicing and removal of equipment. Make piping flexible to permit springing pipe for breaking joints. Provide a 3-valve bypass at each reducing valve.

**F.** Check Valves. Provide swing check valves unless otherwise indicated.

## 3.7 UNIONS, FLANGES AND GASKETS

**A.** Unions. Provide unions where indicated and at each threaded or soldered connection to equipment, tanks and valves, with the following exceptions:

1. Provide three unions at each three-way automatic valve.

2. Only one union is required at each manually operated threaded valve.

3. In refrigerant piping systems only where indicated.

4. None required at compression stops.

**B.** Locate unions so piping can be easily disconnected for removal of equipment, tank or valve.

**C.** Flanges. Provide flanges at each flanged connection to equipment, tanks and valves. Provide matching flange faces at each connection. Tighten fastener system to indicated torque.

## 3.8 INSULATING CONNECTIONS

**A.** Provide electrical insulating flanges where indicated and at the following locations:

1. In each metallic water service connection into a building within five feet of building wall. If possible, install adjacent to valve or cock and above ground.

2. At points of connection between copper water lines and steel domestic water heater tanks.

3. At points of connection between ferrous and nonferrous metallic pipe.

## 3.9 FLEXIBLE PIPE CONNECTIONS

**A.** Align and space piping accurately before installation. Do not use flexible connections to correct misalignment.

**B.** Support piping near equipment to prevent weight of pipe from compressing or extending flexible connection from required installed setting.

**C.** Install as recommended by manufacturer.

**D.** Assemble flexible section with metal retaining rings, built-in braided wire, built-in reinforcement with restriction bolts, or with wire braid cover. Equip flanged assemblies with limit bolts to restrict maximum travel.

**E.** Provide control units for pipe connectors at equipment mounted on vibration isolators, to limit travel.

**F.** Provide pipe guides on each side of each expansion joint as recommended by the joint manufacturer.

**G.** For all expansion joints, use joints with welded, flanged, or threaded ends, and bases for each joint unless otherwise indicated. Use single-element joints with bases as an end anchor where indicated. Use ball joints of stainless steel, malleable iron, ductile iron, carbon steel, bronze, or other alloys suitable for the service intended, in accordance with ANSI B31.1.0.

## 3.10 PROTECTIVE COATING FOR PIPE

**A.** General. Spirally wrap steel pipe buried in ground and below concrete slabs with corrosion-protective tape applied with suitable primer after pipe has been thoroughly cleaned and dried and sharp points removed.

**B.** Tape. Use tape in widths as recommended by manufacturer for pipe size being wrapped. Apply tape tightly with 1/2 inch minimum uniform lap, free from wrinkles and voids. Use approved wrapping machine for sections of pipe exceeding 50 feet of continuous length.

**C.** Priming. Apply primer in accordance with tape manufacturer's recommendations.

**D.** Field Joints, Fittings and Valves. Cover field joints and fittings with two full thicknesses of 10-mil thick tape to provide covering 20 mils thick over all surfaces. Use maximum one inch wide tape and extend wrapping minimum six inches over adjacent pipe covering. Apply tape with adequate tension so tape will conform and adhere tightly to surfaces of fitting without air pockets. Use putty type insulation compounds or molding tapes as recommended by tape manufacturer to fill voids, flange faces around bolts, and other irregular surfaces, to provide smooth, even surface for application of tape wrap.

**E.** Valves. Cover pipe flanges and extend over outer edge of valve flanges or threaded portions of valve body. Give two heavy coats of cool tar enamel

conforming to AWWA C203 to unwrapped surfaces of valves. Allow adequate drying time before backfilling.

**G.** Testing

1. Test wrapped pipe, fittings, and field joints on jobsite, after assembly, with approved high voltage holiday detector, with positive signaling device to indicate flaws, holes, or breaks in wrapping. Conduct testing in presence of the Engineer.

2. Prior to starting test, complete all piping and place in bottom center of trench on temporary blocks to hold pipe high enough to allow testing electrode to be run along underside of pipe.

3. Set peak voltage of holiday detector at 10,000 volts. Do not exceed peak of 20,000 volts as determined by crest voltmeter.

4. Repair holidays and damaged or defective wraps with two complete wraps of tape. Do not cover wrapped pipe until testing and repairs have been completed and approved.

5. After design and repairs have been completed, carefully remove temporary blocks.

**G.** Handling and Storage. Handle and store wrapped pipe in banner to protect wrap from damage. Use padded wide skids or supports for temporary storing of wrapped pipe to prevent cutting of wrap. Where necessary, use wide rubber or canvas slings or cradles.

## 3.11 GAUGES

**A.** General. Provide gauge and gauge connections where indicated. Mount on gauge boards unless shown mounted on piping.

**B.** Gauge Boards

1. Mount in convenient location, where gauges may be easily read, at approximately five feet six inches above finished floor.

2. Construct boards of 12-gauge steel and paint dull black. Mount boards four inches from wall by means of 1/2 inch bolts fastened to wall in rear of boards. Use at least four anchor bolts with chromium-plated heads for each board.

3. Mount brass or laminated plastic indicating plate, 3/4 by 3 inches below each gauge, with service indicated in black lettering.

**C.** Gauge Cocks. Provide at each gauge connection to service main and, in addition, at each gauge installed on gauge board.

**D.** Gauge Siphon. Install at each hot water gauge.

**E.** Gauge Schedule. Provide at locations indicated and in accordance with the following schedule:

| GAUGE SCHEDULE<br>LOCATION | PRESSURE RANGE |
|---|---|
| One set of high and low pressure gauges for each refrigeration system. | As required for system indicated. |
| Low pressure side of air and water pressure reducing valves, and fire protection piping system. | As required for system indicated. |
| Hot water and chilled water piping where indicated. | As required for system indicated. |
| On compressed air tanks. | 0 to 200 psi |

## 3.12 THERMOMETERS

**A.** General. Install thermometers to be easily read by a person standing on the floor of the room. Use straight, angle or remote types to suit installation condition.

**B.** Thermometers for Measuring Liquid Temperatures.

1. Install with extension necks to suit insulation on pipes or the lining of tank.

2. Install so bulb projects into flow stream and is completely immersed on liquid.

**C.** Thermometer Schedule. Install at locations where indicted.

## 3.13 ACCESS PANELS

**A.** Required Locations: Wherever valves, damper operators, fire dampers and similar items requiring servicing and adjustment are concealed. Panels are not required in furred ceilings with removable panels.

**B.** Types

1. In Acoustical Tile Ceilings: Fill-in type installed integral with tile pattern. Fill in with ceiling tile.

2. In Fire Rated Ceilings: Fire rated access panel, fill-in type or flat-faced panel as required.

3. All Other Locations: Flat-faced panel.

## 3.14 PIPE AND VALVE IDENTIFICATION

**A.** General

1. Identify exposed piping systems by means of colored stenciled or prefabricated legends with flow arrows. Apply after painting in accordance with Section 09900 - PAINTING, and cleaning of piping and insulation is completed. In general, provide brass tags on special fittings, valves and other operating devices, as well as equipment, to coordinate with maintenance program.

2. Apply legend and flow arrow at valve locations, at points where piping enters or leaves wall, partition, bulkhead, cluster or piping, or similar obstruction, and at approximately 20-foot intervals on pipe runs.

3. Changes in locations and spacing may be made with approval of the Engineer to meet specific conditions.

4. Wherever two or more pipes run parallel, apply printed legend and other markings in same relative location to be in either vertical or horizontal linearity, as appropriate.

5. Locate to be conspicuous and legible from any reasonable point.

**B.** Labels: Permanent type; painted color bands with stenciled letters, or prefabricated pressure-adhesive cloth tape color labels with color lettering, manufactured for piping identification.

1. Painted Color Bands with Stenciled Letters:

   a. Size of stenciled letter and flow arrows (inches):

| Outside Diameter of Pipe or Covering | Width of Band | Size of Stencil Letter | Minimum Length of Flow Arrow |
|---|---|---|---|
| 3/4 to 1-1/4 | 8 | 1/2 | 2-1/2 |
| 1-1/2 and 2 | 8 | 3/4 | 2-1/2 |
| 2-1/2 to 6 | 12 | 1-1/4 | 4 |
| 8 to 10 | 24 | 2-1/2 | 5 |
| over 10 | 32 | 3-1/2 | 6 |

   b. Marking Schedule: Provide legends and band colors in accordance with ANSI A13.1.
   c. Color of Lettering: Fire water, fire-automatic sprinklers, white; all others, black.

d. Color of Flow Arrows: Same as bands, or black or yellow with contrasting background for easy visibility.

2. Prefabricated Pressure-Adhesive Tape:
   a. Background, Legend and Flow Arrows: Letter size per schedule above (or nearest commercially available size) colors per ANSI A13.1.
   b. Installation: Cloth labels shall adhere tightly and neatly to pipe. Remove completely and reapply any labels that do not adhere, using suitable adhesive.

## 3.15 EQUIPMENT INSTALLATION

**A.** Place equipment in locations and spaces indicated. Move equipment into spaces through openings as required. Disassemble and reassemble equipment or other work necessary to accomplish this work.

**B.** Provide all platforms and hangers required for installation of mechanical equipment. Foundation drawings, bolt settings information, and foundation bolts shall be furnished prior to concrete foundation construction for all equipment.

**C.** Mount equipment on vibration isolation units, concrete inertia blocks, or concrete pads as required, in accordance with the approved Shop Drawings and Contract Drawings.

**D.** Align and adjust equipment and vibration isolators in accordance with the manufacturer's recommendations.

**E.** Install equipment furnished by the Authority in accordance with the above requirements.

**F.** Install mechanical equipment where indicated with V-belts and cast iron machined and balanced V-groove sheaves.

**G.** Key sheaves to shafts and lock with set screws.

**H.** On electric motors NEMA size 48 and smaller, fasten sheaves with hardened knurled cup point set screws against flat surface on shaft.

## 3.16 FIELD TESTS AND SYSTEM BALANCING

**A.** General

1. Perform testing and balancing as necessary to assure that all mechanical systems are operating in accordance with the Contract Documents. The process includes the following:
   a. Balancing of air and water distribution.
   b. Adjustment of all systems to provide design quantities.
   c. Verification of the performance of all equipment and automatic controls.

d. Measurement of power consumption, sound and vibration.
e. Recording and reporting the results.

**B.** Leakage Tests

1. Leak test piping after installation, but before backfilling of in-the-ground lines, or before pouring of slabs, or prior to the application of thermal insulation or concealment in shafts, hung ceilings or other places where leakage cannot be readily observed.

2. Furnish necessary materials, test pumps, gases, and labor required for testing.

3. Notify the Engineer at least three days in advance of tests.

4. After tests, repair any leaks to the satisfaction of the Engineer, and retest to determine if leaks have been remedied.

5. Perform testing of pipe and exhaust stacks when ambient air is approximately constant. When piping is pressure tested, bring each system up to pressure and seal. Before testing, remove nonpressure parts of traps, instruments and specialties. Conduct each test over a period of four hours during which time there shall be no appreciable drop in pressure on gauge. While under pressure, tap welded joints with a hammer to assist in discovering defects or lack of soundness.

6. When testing by air or gas pressure, check joints for leaks by means of soap bubble test.

7. Replace nonpressure parts after initial test and retest piping at operating pressure with steam, water, or instrument air, as appropriate, until joints are proven tight.

8. Tests
   a. Test systems in accordance with the following schedule:

| SYSTEM TESTED | TEST PRESSURE |
|---|---|
| Sanitary sewers, drains and vents within buildings | 5 psig water, minimum |
| Storm drain system | 40 psig water, minimum |
| Sprinkler piping | 200 psig water |
| Domestic water | 150 psig water |
| Refrigerant suction | 250 psig nitrogen and 25-inch vacuum |

| | |
|---|---|
| High-pressure steam, supply and return | 150 psig, water |
| Refrigerant liquid | 450 psig nitrogen and 15-inch vacuum |
| Low-pressure steam, supply and return | 100 psig, water |
| Heating hot-water system | 100 psig |
| Chilled-water system | 150 psig |
| Condenser-water system | 150 psig |

b. Test sanitary sewer, drain and vent within building and storm drain systems in accordance with Massachusetts State Plumbing Code.

b. Test standpipe and hose systems in accordance with NFPA 14.

**C.** Sanitary Piping

1. Test at the completion of rough-in and before back filling or embedment or at times as directed by the Engineer.

2. After plumbing fixtures have been set and their traps filled with water, test entire drainage and vent system with smoke or peppermint.

**D.** Refrigerant Piping

1. After all components of the refrigerant system have been installed and the piping connected, subject the system to a pneumatic test.

2. Test with dry nitrogen before any refrigerant pipe is covered. Test the high and low side of the refrigerant system for the minimum refrigerant leak field test pressure in accordance with ANSI B9.1 for the refrigerant employed in the system.

**E.** Air and Water Systems Balancing and Testing

1. General Requirements. No test will be permitted unless pre-test requirements hereafter specified have been met.
   a. Procure the services of an independent balance and testing agency approved by the Engineer to test and balance air distribution and water systems in accordance with Associated Air Balance Council Specifications for Air Systems and Air Distribution Test and Balance and Chilled and Hot Water Systems Balance.
   b. Provide, maintain, and pay all costs for equipment, instruments, and operating personnel required for tests.

c. Make final adjustments or balancing to equip systems as required for acceptable operating conditions and to meet specified performance.
d. Replace or revise as required, equipment, systems or work found deficient during tests.

2. Pre-Test Requirements
   a. Before operating equipment or systems, make thorough check to determine that systems have been flushed and cleaned as required and equipment has been properly installed, lubricated and serviced. Check factory instructions to see that recommended lubricants have been used.
   b. Use particular care in lubricating bearings to avoid damage by over-lubrication and blowing out seals. Check equipment for damage that may have occurred during shipment, after delivery, or during installing. Repair damaged equipment as approved or replace with new equipment.
   c. After completion of requirements above and immediately before starting completion tests as specified herein, clean or renew air filter media.
   d. Clean pipes free of scale and thoroughly flush piping systems. Provide temporary bypass for all water coils to prevent flushing water from passing through coils. Clean all strainers and valves. Fill all systems with the media required and remove air from the systems by operating the air vents.
   e. Clean all debris from the inside of air handling equipment and plenums and then vacuum clean to remove small particles of rubbish and dust before operating the equipment and before installing outlet faces.

3. Completion Tests
   1) Notify the Engineer at least three days in advance of starting these tests.
   2) Upon completion of pre-test requirements, or at such time prior to completion as determined by the Engineer, operate and test mechanical equipment for at least five consecutive eight-hour days to demonstrate satisfactory overall operation of system.
   3) Operate heating and air conditioning equipment and systems for not less than two eight-hour days for each system at not less than 90 percent of full specified heating and cooling capacities.
   4) Water Systems
      1) Balance each system by means of the balancing cocks and flow indicators. Make water measurements by means of calibrated orifices and portable flow meters or permanent type orifice flanges where indicated. Set automatic control valves to full flow conditions through coils during balancing procedure.
      2) After balancing, take running current readings at circulating pumps. Correct any pump motor which is overloaded as

approved by the Engineer and at no additional cost to the Authority.

3) Determine pump capacities by differential pressure measurements. Adjust water circuits by balancing cocks or automatic flow balancing valves. Permanently mark all balancing cocks after balance is complete so that they may be returned to their correct position if disturbed.

5) If full-load conditions cannot be obtained for above tests, place equipment in proper condition for long shutdown or until such time as post-contract completion tests or pre-season start-up can be made as specified herein. Provide periodic checks as required and conform to manufacturer's recommendations for such shutdowns.

4. Post Contract Completion Tests. If for any reason required full-load operating conditions cannot be obtained at time of completion tests, the Contractor shall return to jobsite when requested by the Engineer and operate equipment systems at such time as will permit proper loading of equipment and systems as required. After notifications, seven calendar days will be allowed to start tests.

5. Pre-Season Start-up. When requested by the Engineer during guarantee period, start up for early heating or cooling season use, equipment and systems that have remained shut down immediately after completion tests and that have not performed full load completion and post-contract completion tests.

6. Test Agency Reports. The test and balance agency shall record and submit to the Contractor for forwarding to the Engineer, complete test data and balance report certified by a Registered Professional Engineer. This report shall include the data for each system balanced as listed below:
   a. Installed Equipment:
      1) Manufacturer of pump and motor
      2) Size of pump and motor
      3) Capacity and head of pump
      4) Motor, hp, volts, phase full load amps
   b. Design Conditions:
      1) GPM
      2) Pressure at pump suction and discharge
      3) Motor hp
      4) RPM or pump
      5) GPM at each coil
      6) BHP of motor
   c. Field Test Results:
      1) GPM
      2) Pressure at pump suction and discharge
      3) RPM of pump
      4) Operating amps
      5) Motor Operating BHP

6) Temperature water at pump
7) GPM at each coil

## PART 4 - MEASUREMENT AND PAYMENT

### 4.1 GENERAL

**A.** No separate measurement or payment will be made for work required under this Section. All costs in connection therewith shall be considered incidental to the item or items of work to which they pertain.

**END OF SECTION**